Assimilation of Dual-Polarimetric Radar Observations with WRF GSI

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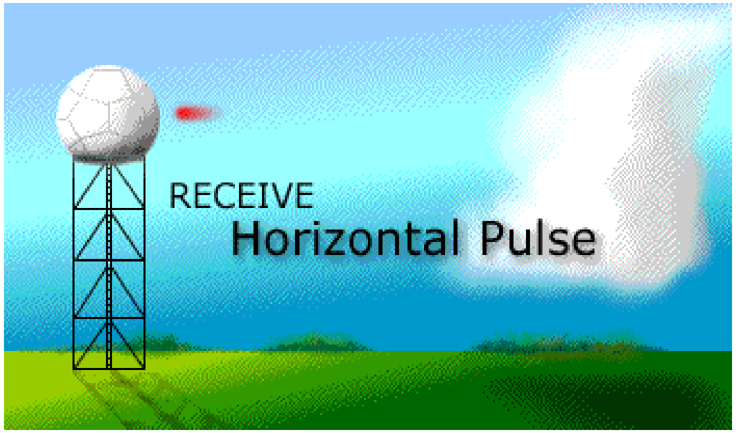
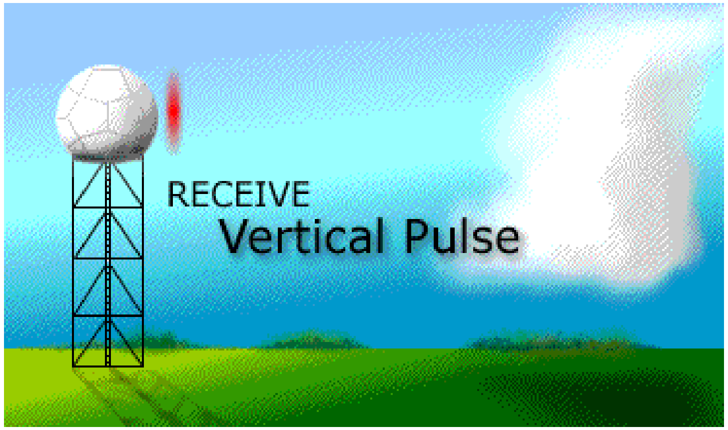
Dual-Polarimetric Radar

Horizontal and vertical signals: more info about the type, shape, and size of the hydrometeors – more accurate estimates of precipitation and cloud particles.





Variables:

Z_H: Horizontal reflectivity

V_R: Radial velocity

Z_{DR}: Differential reflectivity $Z_{DR} = 10 \log10(Z_H/Z_V)$

ρ_{HV}: Correlation coefficient, the coefficient between the horizontal and vertical power returns.

Φ_{DP}: Differential phase, the measured phase shift between horizontal and vertical pulses

SW: Spectrum width, measures the consistence of the phase shifts

Motivation and Goals

- *Only a few* studies have been done assimilating real dual polarimetric data in storm scale forecasting.

- NWS recently completed upgrade of NEXRAD radar network to include dual-polarization capabilities. Migrate to use of S-band data.

- Project goal is to assimilate dual-pol Doppler radar observations and enhance the implementation of dual-pol radar data in NWP.

- Investigate the impact of the dual-pol radar variables on the initial fields and short-term forecast.

Model and Procedure

- WRF model ARW v3.3
- GSI v3.2
- Assimilation procedure:
- Reflectivity is used by the Global Systems Division (GSD) cloud analysis to improve precipitation analysis
- Zdr information is added in calculation of rain amount in GSD cloud analysis package.

Radar Reflectivity Operator

GSD Cloud Analysis for rain:

Kessler (1969):

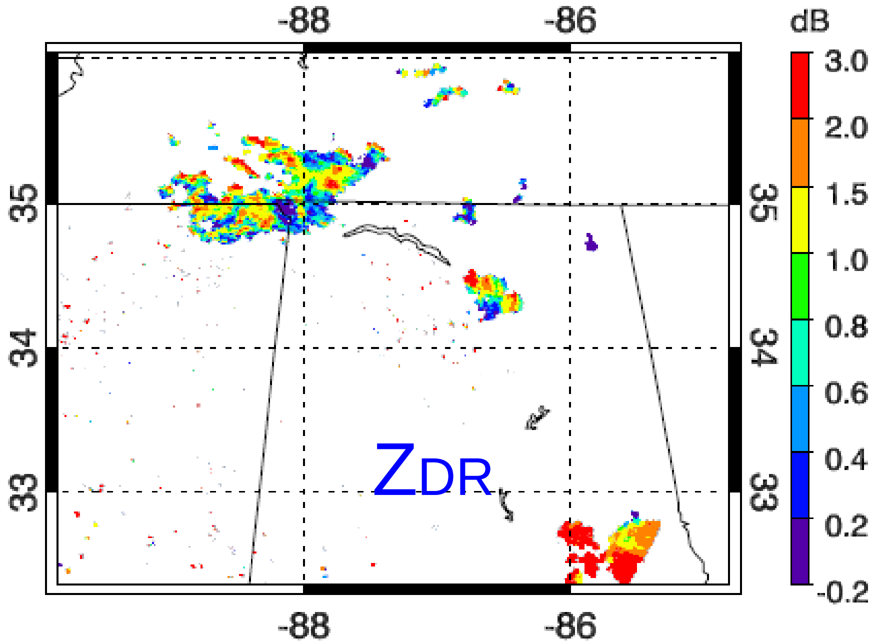
$$q_r = a \cdot (\rho \cdot \mathrm{arg})^b$$

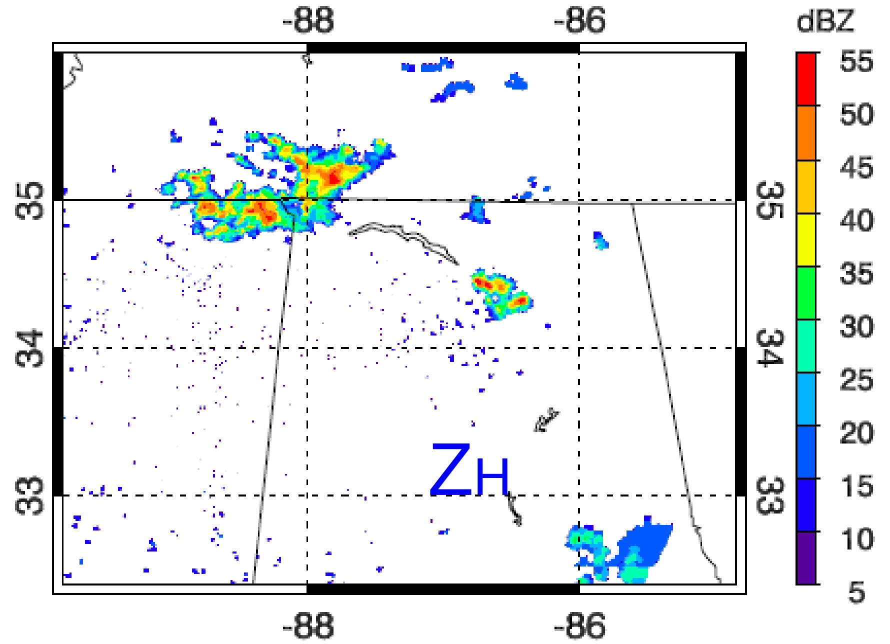
where $\mathrm{arg} = 10.0^{(0.1 \cdot dBZ)}$

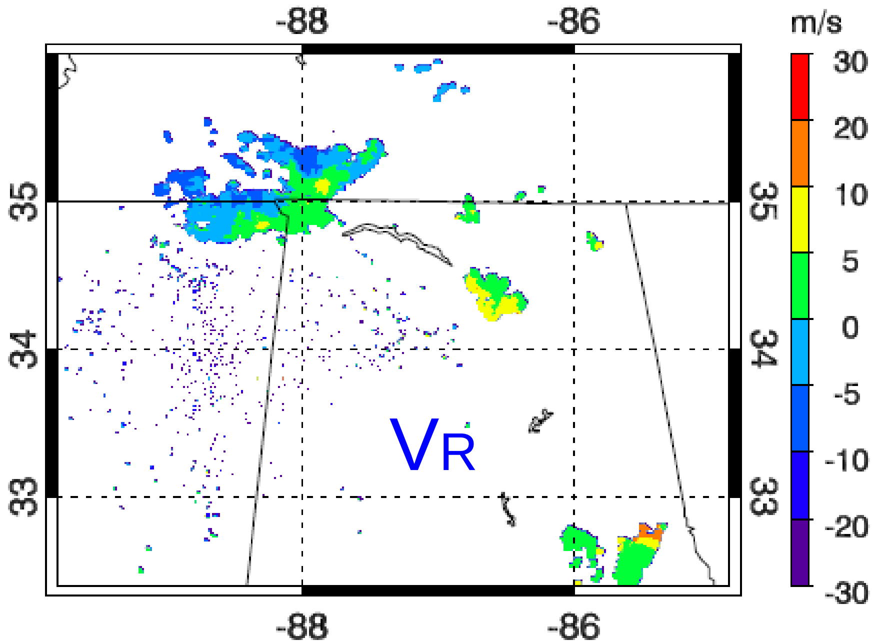
With Zdr, using Ulbrich and Atlas (1984):

$$q_r = 1.28 \times 10^{-4} Z_H \cdot Z_{DR}{}^{-1.94}$$

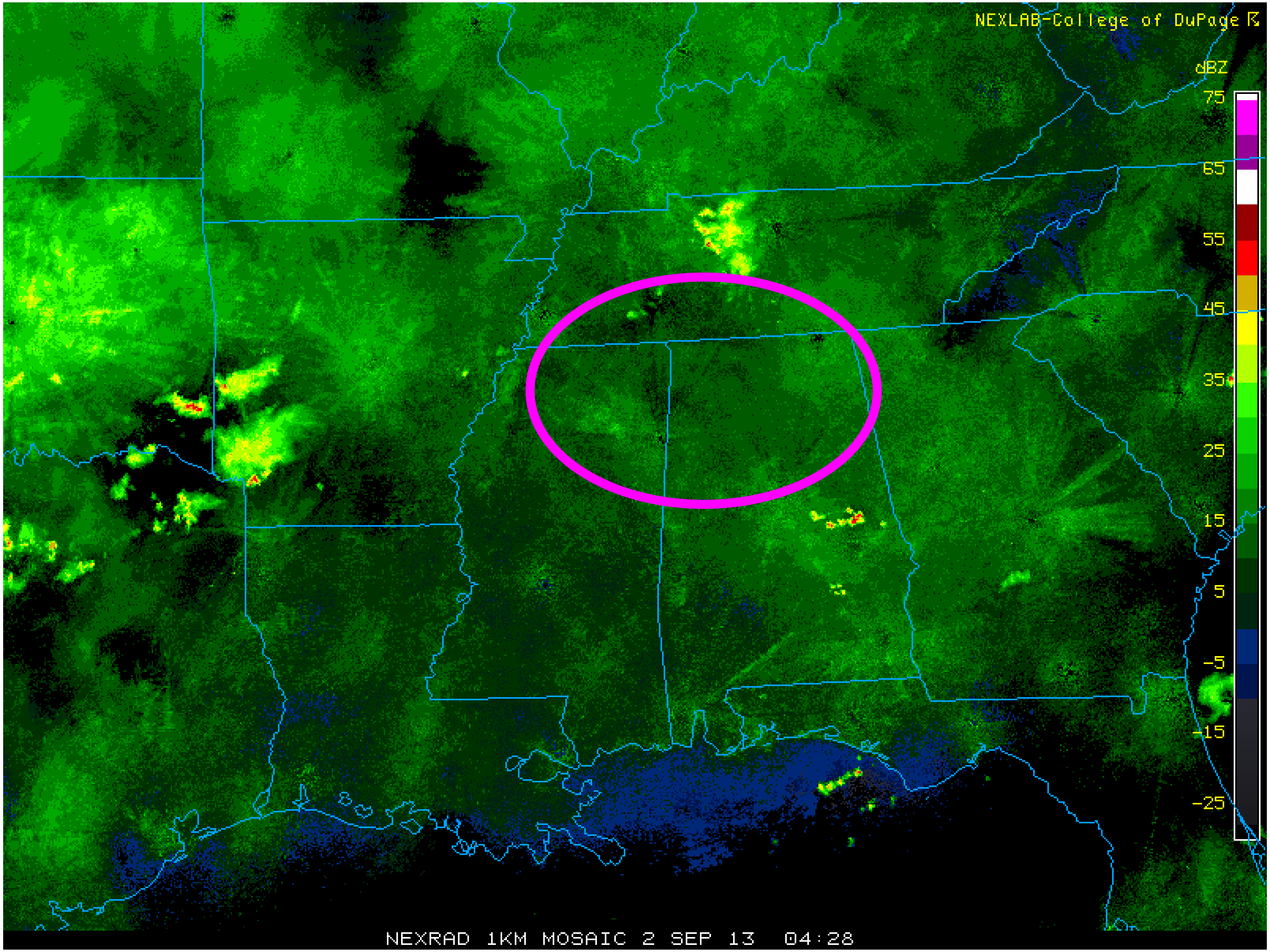
Sample Data: 0631 UTC 2 September 2013







Case Study: 2 September 2013

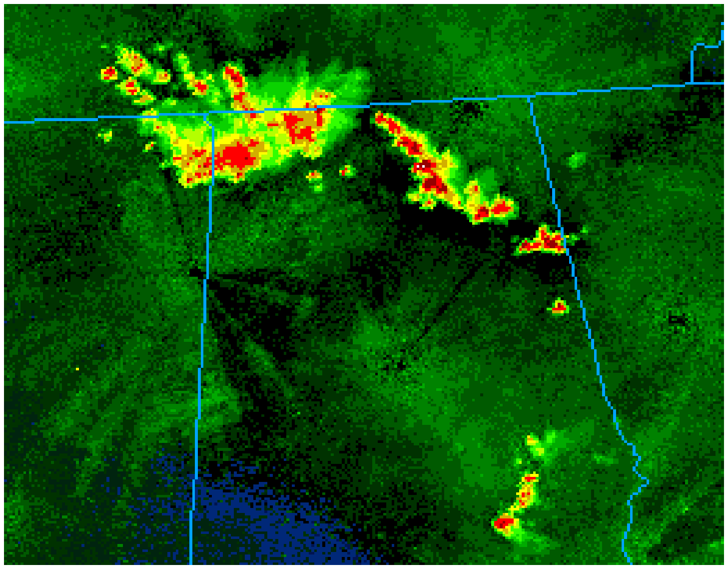


Data Assimilation Experiments

Experiment	Radar Data Assimilation	Variables
CTRL	N/A	N/A
ZH	0600 UTC 2 September 2014	Z_H
ZHZDR	0600 UTC 2 September 2014	Z_H and Z_{DR}

Reflectivity at 0600 UTC 2 September 2013:

NEXRAD



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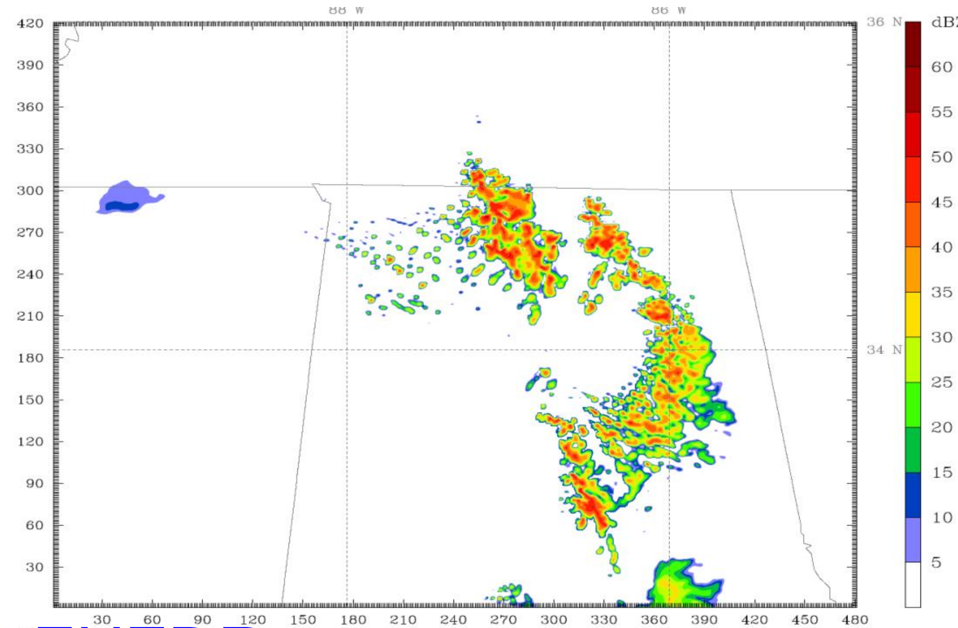

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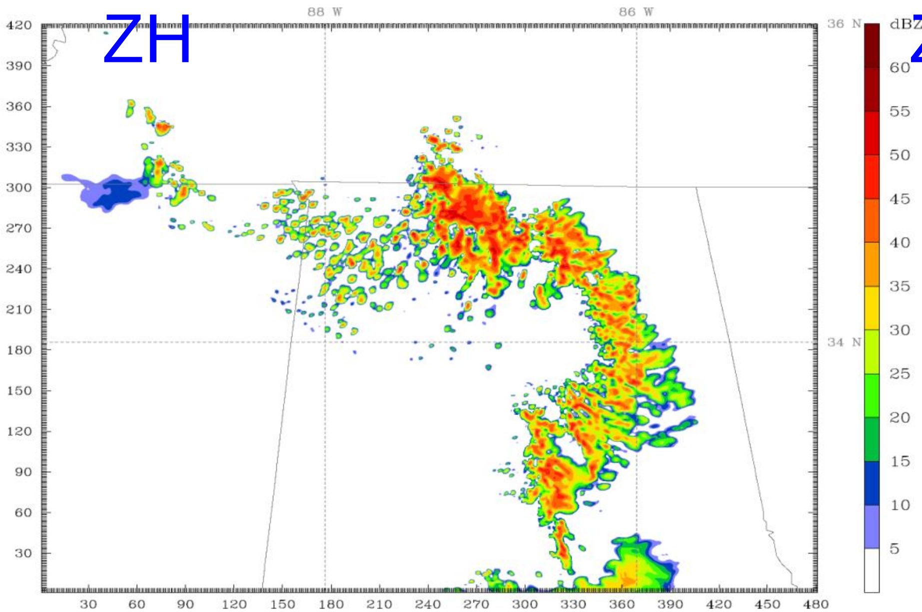
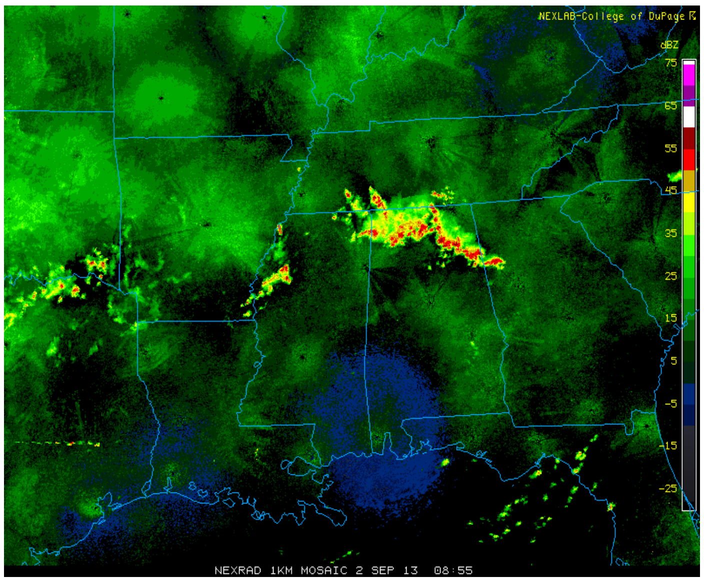


ZHZDR

Forecast Validation 0900 UTC 2 September 2013

NEXRAD



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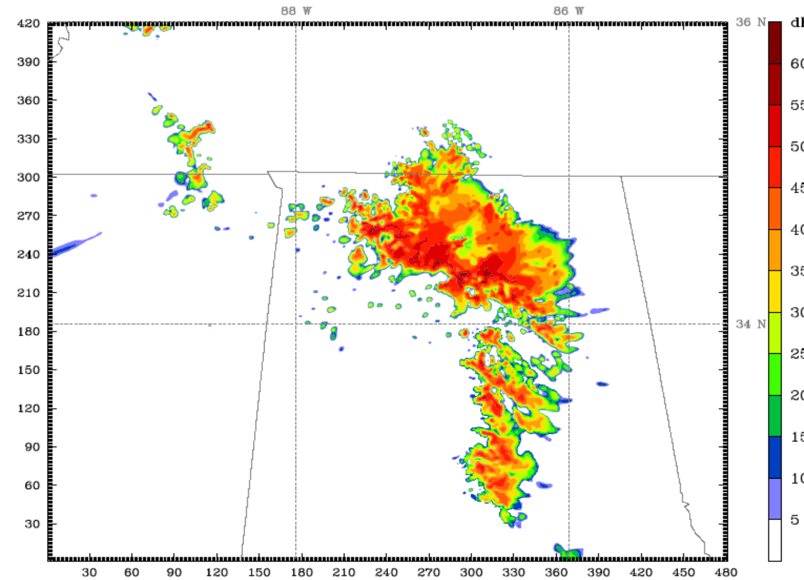

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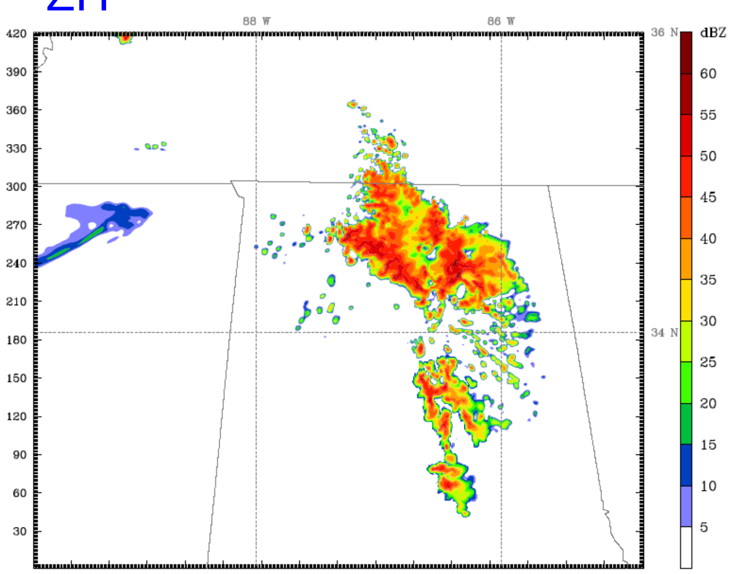
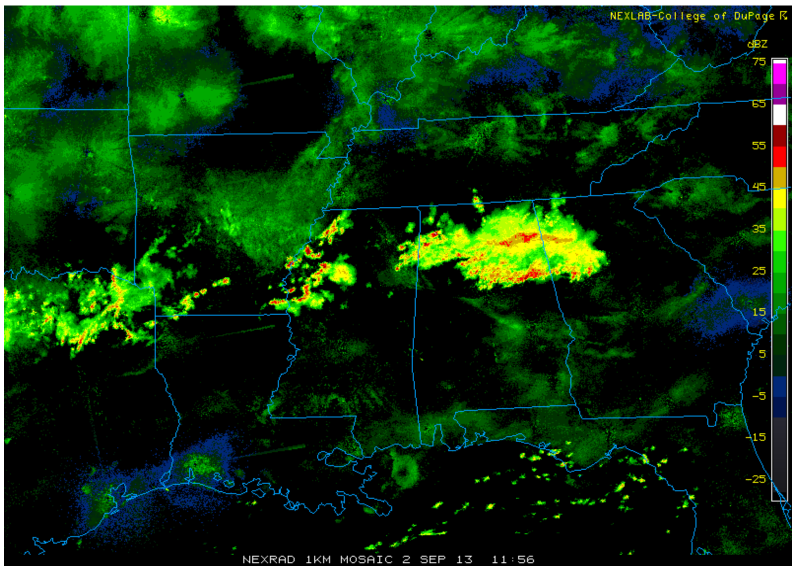


ZHZDR

Forecast Validation 1200 UTC 2 September 2013

NEXRAD



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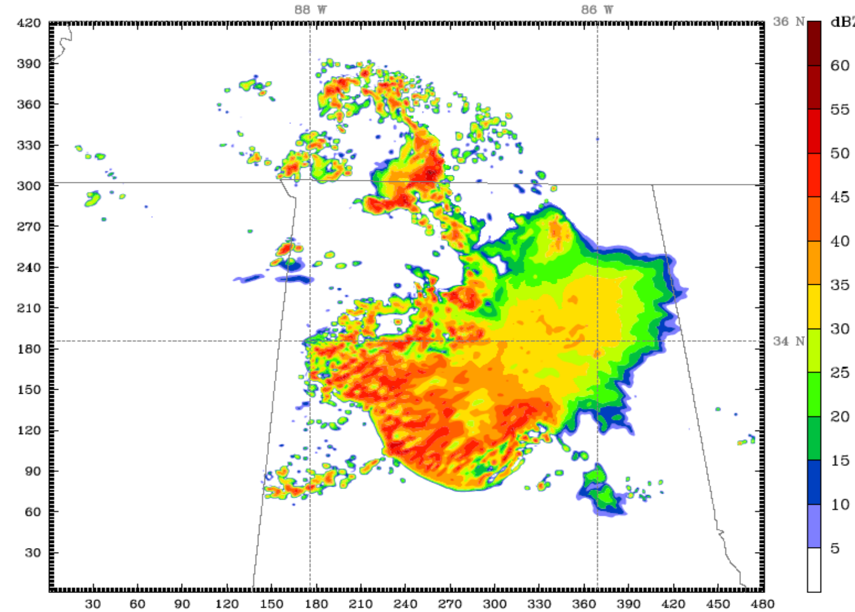

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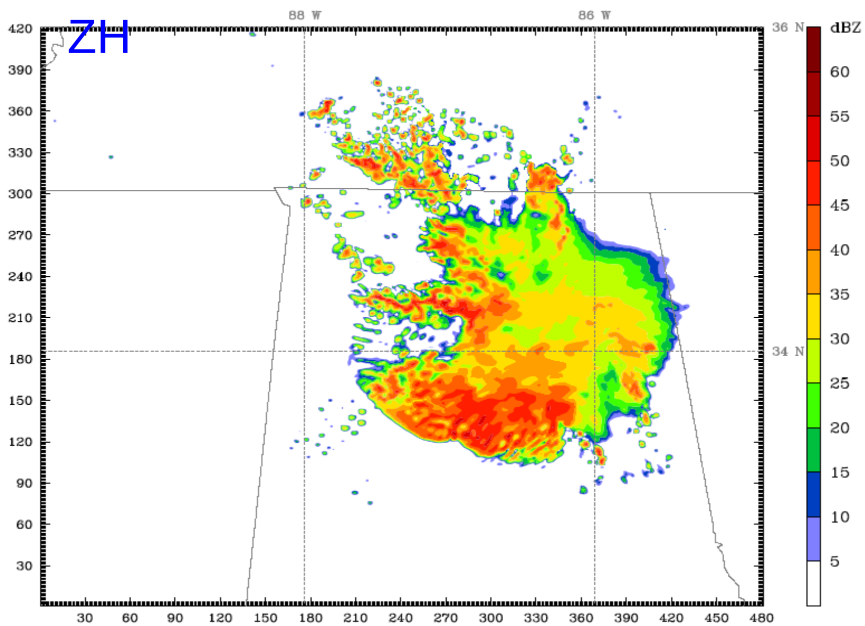

ZHZDR

Summary and Future Work

- The dual-polarimetric variable Z_{DR} has been implemented in GSI v3.2 through GSD cloud analysis package.
- The impact of dual-polarimetric variable Z_{DR} can be seen in the fields of temperature, hydrometeor, and moisture.
- Preliminary results showed the impact of dual-polarimetric variable.

Thoughts:

1. Z_{DR} is only used for rain water with Kessler (1969), can we use it for other hydrometeors;
2. Convective vs. Stratiform region;
3. Use dual-polarimetric variables for particle type and parameters

Summary and Future Work (cont.)

- Implementation of dual-polarimetric radar variables for snow and graupel or hail.
- More case studies and continuous assimilation.
- Investigation of the impact of dual-polarimetric radar variables.
- Impact of dual-polarimetric radar variables for different microphysical options/parameters.
- Sensitivity studies with different radar operators.
- Sensitivity studies on background error matrix and observational error.